Riparian Function

Factors Considered by the Service in the Negotiation and Evaluation of a Riparian Timber Harvest Strategy for the DNRC HCP

To assess the adequacy of riparian conservation proposals, the Service considers a suite of component riparian functions that includes stream bank stability, shade, litterfall and nutrient input, large woody debris recruitment, floodplain function, sediment/bedload transport, and microclimate factors that can affect both aquatic conditions and the short and long-term function of the riparian forest ecosystem. Because these ecological elements interact in complex ways, the adequacy of riparian conservation measures is based on a synthesis of judgments of the relative levels of individual function based on published and regional literature. For example, judgments about large woody debris function for this HCP will be based on the riparian buffer widths, the probability of (functionally-sized) tree fall in relation to distance from the stream, and site-tree heights of dominant and subdominant species in a mature riparian forest.

The adequacy of the riparian conservation measures in the proposed DNRC HCP will be judged at several spatial scales and with consideration of the management frameworks already in place or likely to be implemented in the near future. One special scale is the stream reach scale. However, larger policy and acceptable risk considerations should consider the forested landscape in Montana that supports HCP fish species, such as bull trout, and the baseline conditions within those component watersheds or core areas for HCP fish species. To that end, an analysis was done to estimate the condition of riparian forest stands, the type of representative streams they support, and the area and distribution of riparian management zones that might occur with assumed applications of the proposed HCP. The riparian timber harvest conservation strategy under the HCP addresses the riparian functions that support the habitat components important for the HCP fish species. In addition, the sediment reduction strategy also addresses these functions as well. The individual measures of these strategies would be applied programmatically.

The value of the riparian conservation measures in the DNRC HCP proposal should accrue over time as riparian and instream conditions improve through passive (conservation) and active (restoration) activities. Conversely, short-term risks that are expected to become apparent may be accepted in order to achieve the overall conservation goals and desired future conditions. Temporal factors that were taken into account in the consideration of the HCP proposal were the following (although not limited to): 1) the rate of timber harvest (and other forest and grazing management activities), road management actions (inventories, construction, reclamation, etc.) grazing management (license inspections/renewals, vegetation surveys, corrective actions), conservation and restoration actions, transportation planning, and MEPA processes on HCP project lands; and 2) the term length of the Permit as influenced by the proposed time to successfully fulfill the full complement of minimization and mitigation measures developed in the HCP.

The rate of riparian timber harvest by DNRC on HCP project lands (i.e., 32 to 64 acres per year) was an important consideration in determining the effects on riparian functions as it relates to effects on HCP fish species. For example, historical rates of harvest (prior to SMZ laws) may be different than present annual rates of harvest because of variable wood products market and other factors. In addition, conversion of timber lands, especially on adjacent private lands, to other uses has occurred at high rates and continues to increase at a substantial rate as population growth expands in such areas as the upper Flathead Valley, Bitterroot Valley, and the Swan Valley (although a slower rate in the Swan). There are obviously many ecological benefits to maintaining riparian areas within an actively managed forest rather than within developed areas. DNRC acknowledged this issue and developed the transitions lands strategy for the HCP in order to keep intact over the long-term the riparian conservation values in major river valley corridors within the HCP project area.

Riparian forest conditions are thought to vary with site productivity, dominant species, successional pathways, and the stand age proposed to represent mature riparian forest conditions. Generally, mature riparian forest exhibits a wide range of variation of tree growth, (e.g., stand productivity) according to such factors as elevation, riparian land form (floodplain, slope, terrace), air and soil temperature, precipitation, etc. More productive sites have taller trees that grow faster in diameter (in addition to understory shrubs) and therefore would be expected to better provide litter-fall, shade, and LWD than similarly aged riparian forests on less productive sites. Therefore, managing riparian stands for future desired conditions must take into account site productivity by site class (a measure of an area's relative capacity for producing timber). This approach provides a simple way to ensure that a riparian forest stand will produce the desired level of stand conditions important for fish. The DNRC HCP incorporates future stand conditions at age of maturity (i.e., site class) in development of the habitat complexity conservation strategy.

Managing for the diversity of riparian forest conditions is a recognized ecological feature of the riparian zone, and was incorporated into the DNRC HCP. Although forest management is generally designed for conifer-dominant stands, some riparian sites were unlikely to have ever been conifer-dominant and other currently mixed conifer-hardwood sites or shrub-dominated sites with low numbers of conifers have been maintained for many decades and provide diversity over the landscape. This DNRC HCP strategy is consistent with an ecological goal to allow disturbance and recovery processes to take place as normally as possible (Bisson et al. 1997). Under the DNRC HCP, management of riparian areas should help to maintain the ranges of conditions produced by natural disturbance regimes, including a frequency distribution of riparian forest successional stages that resembles those in un-managed watersheds over long time periods.

The design of riparian management zones and determination of allowable levels of disturbance therein, should be balanced with the silvicultural treatments of riparian ecosystems (stand growth and succession) to maintain, or accelerate, achievement of riparian functions in the short-term. However, it is recognized that instream conditions may lag behind achievement of desired riparian condition hence longer periods of time may be needed in order to detect the subtle changes that would benefit HCP fish species. Riparian functions can be achieved well before conditions in the channel become optimum because in some cases active management may forgo short-term large woody debris (LWD) input. In other words, instream conditions are often the result of episodic riparian and watershed disturbances that may have occurred over many decades (Sullivan et al. 1987). Instream conditions are generally not tightly linked to riparian management, consequently, conservation measures should be designed to assure that riparian conditions are functional rather than instream conditions. The DNRC HCP was designed to focus on conserving the most important riparian functions that would benefit HCP species, both in the short-term and the long-term.

The Origin of the USFS INFISH Standards

The Forest Ecosystem Management Assessment Team developed a report that provides a conceptual framework for understanding the interactions of riparian areas, stream ecology, and fish habitats (FEMAT 1993). The riparian process effectiveness curves (the FEMAT curves), which are based on tree heights in the FEMAT report, have been used as an interim basis for establishing federal aquatic conservation strategies and proposed by some for use in framing revisions to state forest practice rules. The FEMAT curves show the effectiveness of riparian processes as a function of distance from stream channel and suggest that riparian processes are 100% effective within a maximum distance from a stream channel, and that additional effectiveness is not achieved beyond that point. Published scientific literature and technical reports support the notion that the patterns are asymptotic. The FEMAT curves also suggest that the effectiveness of the riparian processes decreases rapidly and non-linearly with increasing distance from the streambank and this is supported in the scientific and technical literature as presented later in this response.

Riparian forests exhibit a wide range of variation of tree growth (e.g., stand productivity) according to such factors as elevation, riparian land form (floodplain, low terrace, high terrace, or slope), herbivory, temperature, and topographic moisture (Gregory et al 1991). The more productive sites typically play a greater role in meeting riparian function than less productive sites. More productive sites have taller trees that grow faster in diameter (in addition to more understory shrubs) and therefore are expected to better provide litter-fall, shade, and LWD than similarly aged riparian forests on less productive sites. A common metric to determine the productivity of a riparian site (and ultimately how fast and tall a tree would grow) is the "site index." The site index is a measure of forest productivity expressed as the height of the dominant trees in a stand at an index age – in other words, the height of which a tree will grow under forest conditions in 100 years for most old-growth species.

FEMAT (1993) recommended to federal agencies (BLM, Forest Service) that riparian buffer widths be based on "site potential tree height," which is the distance represented by the approximate mid-point of site classes (i.e., site conditions) projected to a stand age of 100 years, for example. Site potential tree height, as defined by FEMAT, is a "tree that has attained the average maximum height possible given the site conditions where it occurs." As indicated above, more productive sites would be expected to better provide various riparian functions than similarly aged riparian forests on less productive sites. Calculation of riparian stand requirements by productivity site class (site class is determined based on groupings of the site index) using existing yield tables (usually reported by the USDA Natural Resource Conservation Service, or U.S. Forest Service) is often an approach that gives landowners a simple way to manage and conserve riparian forests with a high assurance of attaining or conserving appropriate riparian functions.

FEMAT (1993) established a generalized set of curves based on tree height (distance from channel) as the basis for establishing riparian buffer widths for Federal land management agencies (BLM, Forest Service). Federal agencies have utilized site potential tree height distance for the determination of riparian reserve widths in order to address management of aquatic species that are threatened and endangered. The set of generalized curves (the FEMAT curves) indicate the riparian forest effect on streams as a function of buffer width for four principle ecological functions, which are root strength, litter fall, shade, and coarse woody debris (FEMAT 1993). The FEMAT curves suggest that a buffer width of one site potential tree height (on both sides of the stream channel) provides close to 100 percent shading effectiveness and similarly provides for maximum availability of coarse woody debris in the stream. A buffer width of one-half the height of site potential tree height provides close to maximum litter-fall and for maximum effectiveness for root strength (i.e., streambank stability).

Federal programs like INFISH (USFS 1995) originally adopted interim riparian buffer widths of two site potential tree heights (300 feet) on both sides of fish-bearing streams until watershed analysis is performed, presumably to develop better site-specific prescriptions and practices (O'Laughlin and Belt 1995). The rationale for doubling of the site potential tree heights was not clear, but may have to do with responding to declining stocks of fish (Nehlsen et al. 1991) and riparian dependent wildlife (FEMAT 1993). No functional explanation was provided in any of the federal documents, but some have suggested that it may have to do with recruiting large woody debris (LWD) into the buffer zone (for an unstated purpose) (O'Laughlin and Belt 1995). However, it may be due to studies that suggest non-channelized sediment flow rarely travels more than 300 feet and that 200-300 foot riparian "filter strips" are generally effective at protecting streams from sediment than from non-channelized flow (INFISH 1995, Packer 1967, Swift 1986, Burroughs and King 1985; 1989). Still others have suggested that the large buffer widths were a conservative approach to be implemented during the 18-month interim period (1998 - 2000) until watershed analyses could be performed and that the main purpose of this approach was to streamline Section 7 consultations under the Act (O'Laughlin and Belt 1995).

The Federal agency buffer widths based on the FEMAT curves have been criticized as not science-based, too restrictive for management, one-size fits all, based on upland forest data, too subjective, and lacking new scientific information about riparian process relationships (Oregon Forest Industries Council 1999). The conservative approach of applying two site potential tree heights may be due to federal mandates and regulations that federal management strategies have to apply over broad geographic areas that occur throughout the Pacific Northwest (Light et al. 1999). INFISH is a more risk-averse strategy because of the requirement by federal agencies to promote recovery of listed species under the Act, whereas, non-federal entities are required only to allow for, or not preclude recovery.

The Service is not aware of evidence that HCP fish species including the most sensitive, bull trout, require 300-foot buffers. However, the scientific literature contains many studies that document risks of ground disturbing and harvest activities within one site-potential tree height. As expressed above, functions such as bank stability, nutrient input, and shading generally occur near the stream. Large woody debris recruitment generally approaches its maximum within a site potential tree height or less. Any further distance beyond a site potential tree height clearly shows diminishing returns. The DNRC HCP riparian timber harvest conservation strategy was developed with the understanding that the majority of stream and riparian functions are addressed within a site-potential tree height of the stream.

The Origin of DNRC's HCP Buffer Widths
An existing forest management rule (ARM 36.11.425) requires DNRC to establish an RMZ on fish-bearing streams equal to the average site potential tree height (SPTH) at stand age 100 years. Tree height at 100 years is determined using site index curves developed by the USFS Rocky Mountain and Intermountain Research Stations (USFS 1980). The site index of a stand is determined by measuring tree height and age directly from suitable index trees located within the SMZ portion (first 50 feet from the edge of the stream channel) of the RMZ.

Site index tree height at age 100 years for a given site was selected by DNRC as the most practical and effective indicator for identifying the area where forest practices are most likely to affect riparian functions and biological objectives addressed under this strategy. The site index tree height at age 100 years in most DNRC streamside riparian stands generally ranges from approximately 80 to 120 feet. The actual site index is largely dependent on the soil and climate of the landscape and other factors affecting the specific productivity of an individual site, but it is measurable at each site.

DNRC, with assistance from the Service, designed the riparian timber harvest conservation strategy to ensure that post-harvest riparian stand conditions are adequate to maintain the riparian functions most important to HCP fish species habitat. Hence, under the HCP, all Class 1 streams would receive an RMZ buffer width based on a 100-year site index tree height. Additionally, the HCP would require retention of a 50-foot no-harvest buffer along all Class 1 streams. The HCP riparian timber harvest strategy will result in the retention of all trees and shrubs within 50 feet of a stream, and nearly all shrubs, sub-merchantable trees, and at least 50 percent of the trees greater than or equal to 8 inches dbh from within the remaining RMZ. Therefore, it is expected that on average, approximately 80 percent of the basal area will be retained within the RMZ following this prescription. In addition, DNRC has indicated that it is likely that a majority of timber harvests in the RMZ will retain a higher concentration of trees adjacent to the no-harvest buffer, which in turn would reduce or eliminate effects to microclimate (Final HCP, Chapter 2, page 2-66). DNRC anticipates conducting approximately 32 to 64 acres of RMZ harvest adjacent to Class 1 streams on an annual basis within the HCP project area.

DNRC based the strategy on scientific research on riparian buffer widths required to maintain adequate levels of buffer function, including LWD recruitment potential, retaining adequate levels of shade, and maintaining streambank stability necessary to provide habitat suitable for supporting HCP fish species (Brown and Krygier 1971; Martin et al. 1985; FEMAT 1993; Davies and Nelson 1994; Gomi et al. 2003; Sugden and Steiner 2003). This strategy was intended to focus on those critical riparian functions most likely to be affected by timber harvest and, at the same time, the most influential on the habitat of the HCP fish species. Riparian functions specifically addressed in this strategy are LWD recruitment, stream shading (used as a surrogate for stream temperature), and streambank stability. However, the riparian harvest conservation strategy is expected to meet or contribute to Montana DNRC HCP management objectives for sediment and microclimate functions as well. The values reported in the literature for shade retention, LWD recruitment, bank stability, nutrient loading and chemical filtering are all well within the range of 100-year site index tree heights occurring adjacent to streams supporting HCP fish species on forested trust lands. These values and riparian function under the HCP are evaluated below.

Evaluation of the DNRC HCP Riparian Timber Harvest Conservation Strategy

The HCP riparian strategy was intended to focus on those critical riparian functions most likely to be affected by timber harvest and, at the same time, the most influential on the habitat of the HCP fish species: LWD recruitment, stream shading (used as a surrogate for stream temperature), and streambank stability (used as a surrogate for channel stability, form, and function).

LWD Recruitment - The potential recruitment of LWD to stream channels from adjacent forest stands is generally limited to an area located within a width equal to or less than the 100-year site index tree height as measured from the edge of the stream channel. This conclusion is well documented in the literature and is commonly used to delineate the width of SMZs or RMZs. In a study of streams in southeast Alaska, Murphy and Koski (1989) found that almost all (99 percent) identified sources of woody debris in streams were within 100 feet of the stream bank. Nearly half of the woody debris came from trees located on the lower bank (less than 3 feet away) and 95 percent was from trees within 66 feet of the stream. McGreer (1994) reported a study by Andrus and Froehlich in the Oregon Coast Range in 1992 in which 70 to 90 percent of all LWD recruitment was found to occur within 100 feet of streams. McDade et al. (1990) reported that 85 to 90 percent of LWD recruitment comes from within 100 feet of stream channels in western Oregon. Robison and Beschta (1990) concluded that the probability of recruitment was primarily a function of tree distance from the stream and that part of the tree height that would provide woody debris of a minimum diameter to a stream.

Hence, the DNRC HCP establishes a streamside buffer (RMZ) for all Class 1 streams based on a 100-year site index tree height. As described in the Final EIS/HCP (USFWS and DNRC 2010), the proposed HCP meets LWD targets for all modeled riparian stands except one, although this stand does demonstrate an increasing trend in LWD during the period in which it does not meet its targets. The HCP does allow harvest in the no-harvest buffer and management in the remainder of the RMZ in accordance with the SMZ law under certain conditions. However, the total acres treated under this provision, when combined with the amount of RMZ in a non-stocked or seedling/sapling stand, may not exceed 20 percent of the DNRC Class 1 RMZ acres for a given AAU, which is expected to be within the range of natural disturbances historically occurring in the project area (Final HCP, Chapter 3, page 2-82).

Stream Shading (Temperature) - The effectiveness of various widths of riparian forest in providing shade to streams is also closely tied to 100-year site index tree heights. Studies have shown that approximately 80 percent of shade effectiveness occurs within 0.5 SPTH, and 90 percent effectiveness occurs within 0.7 SPTH (Oregon Forest Industries Council 1999). A review of the available literature by Castelle and Johnson (2000) concluded that maximum shade produced in forest stands located adjacent to a stream was achieved within 56 to 98 feet of the stream channel. Steinblums et al. (1984) evaluated the effectiveness of 40 different streamside buffer widths in western Oregon and concluded that 90 percent of maximum angular canopy density (a measure of the density of canopy actually capable of shading the stream) could be obtained within a 56-foot buffer.

Hence, the DNRC HCP requires retention of a 50-foot no-harvest buffer along all Class 1 streams within the RMZ. As described in the Final EIS/HCP (USFWS and DNRC 2010) the

DNRC would maintain or increase shade levels for all modeled stand types with one exception, although all stand types provided shade levels at least 10 percent greater than the established targets. Based on the Final EIS/HCP results of the modeled stream shading, the HCP is expected to maintain water temperatures in the HCP project area. Given the limited number of acres in the RMZ that would be treated each year, the allowances for harvest in the 50-foot buffer are not expected to contribute measurable changes in stream temperatures. Stream temperatures would be monitored to substantiate these conclusions and addressed through adaptive management if monitoring goals are not achieved.

Streambank Stability (Channel Form and Function) – The FEMAT curves indicate that a buffer width of one-half the height of site potential tree height provides close to maximum litter-fall and for maximum effectiveness for root strength (i.e., streambank stability). Hence, the DNRC HCP requires retention of a 50-foot no-harvest buffer along all Class 1 streams within the RMZ. As the bulk of organic nutrients tend to be input from an area within approximately one-half the SPTH (Oregon Forest Industries Council 1999; Castelle and Johnson 2000), the HCP riparian timber harvest strategy should provide an adequate mechanism for the range of nutrient loading rates that would be expected to occur in the different regions of forested western Montana. Furthermore, because most chemical filtering by a riparian zone occurs within a width equal to approximately a 100-year site index tree height, the strategy will help to provide the range of chemical filtering rates that would be expected to occur in the different regions of forested western Montana (Castelle and Johnson 2000).

Conclusion

The DNRC HCP riparian timber harvest conservation strategy addresses the critical riparian functions described as most important to HCP fish species. The width of an effective riparian buffer is a commonly used function to measure aquatic habitat integrity. A buffer width of about 0.75 tree height is effective at protecting over 80 percent of the LWD functions. Other ecological functions (stream shading, root strength, and litter fall) are effective with smaller riparian buffers (FEMAT 1993). The analysis of the effects of the riparian timber harvest on these riparian functions in the Final EIS/HCP (2010) provides a high degree of certainty that the buffer widths and associated RMZ prescriptions will likely avoid or minimize the effects on riparian functions that support the habitat needs of the HCP fish species.

Literature Cited

Bisson, P.A., G.H. Reeves, R.E. Bilby, and R.J. Naiman. 1997. Watershed management and salmon dynamics: desired future conditions. In: D.A. Stouder, P.A. Bisson, and R.J. Naiman, editors. Pacific Salmon and Their Ecosystems. Chapman and Hall, New York.

Brown, G.W. and J.T. Krygier. 1971. Clear-cut logging and sediment production in the Oregon Coast Range. Water Resources Research 7:1189-1198.

Burroughs, E.R. and J.G. King. 1985. Surface erosion control on roads in granitic soils. In, Proceedings: ASCE Committee on Watershed Management, Denver, CO. Pp. 183-190.

Burroughs, E.R. Jr., and King J.G. 1989. Reduction of soil erosion on forest roads. U.S. Forest Service, Intermountain Research Station, General Technical Report GTR-INT-264, Ogden, Utah.

Castelle, A.J. and A.W. Johnson. 2000. Riparian vegetation effectiveness. Technical bulletin No. 799. National Council for Air and Stream Improvement, Research Triangle Park, North Carolina.

Davies, P.E. and M. Nelson. 1994. Relationships between riparian buffer widths and the effects of logging on stream habitat, invertebrate community composition and fish abundance. Australian Journal of Marine and Freshwater Research 45:1289-1305.

FEMAT (Forest Ecosystem Management Assessment Team). 1993. Forest ecosystem management: an ecological, economic, and social assessment: report of the Forest Ecosystem Management Assessment Team. U.S. Forest Service, Washington D.C.

Gomi, T., R.D. Moore, and A.S. Dhakal. 2003. Effects of riparian management on stream temperatures in headwater streams, coastal British Columbia, Canada. Presented at International Association of Hydrological Sciences General Assembly, Sapporo, JAPAN.

Gregory, S.V., F.J. Swanson, W.A. McKee, and K.W. Cummins. 1991. An Ecosystem Perspective of Riparian Zones. Bioscience 41(8): p.540-551.

Light, J., M. Holmes, M. O'Connor, E.S. Toth, D. Berg, D. McGreer, and K. Doughty. 1999. Design of effective riparian management strategies for stream resource protection in Montana, Idaho and Washington. Native Fish Habitat Conservation Plan Technical Report #7. Plum Creek Timber Company, Seattle, Washington.

Martin, M.A., D.K. Shiozawa, E.J. Loudenslager, and J.N. Jensen. 1985. Electrophoretic study of cutthroat trout populations in Utah. Great Basin Naturalist. 45:677-687.

McDade, M.H., F.J. Swanson, W.A. McKee, J.F. Franklin, and J. Van Sickle. 1990. Source distances for coarse woody debris entering small streams in western Oregon and Washington. Canadian Journal of Forest Research 20:36.

McGreer, D.J. 1994. Effectiveness of streamside protection regulations in western Montana – a comparison with the scientific literature. Unpublished report on file at Western Watershed Analysis, Lewiston, Idaho.

Murphy, M.L. and K.V. Koski. 1989. Input and depletion of woody debris in Alaska streams and implications for streamside management. North American Journal of Fisheries Management 9:427-436.

Nehlsen, W., J.E. Williams, and J.A. Lichatowich. 1991. Pacific salmon at the crossroads: stocks at risk from California, Oregon, Idaho, and Washington. Fisheries 16(2):4-21.

O'Laughlin, J. and G.H. Belt. 1995. Functional approaches to buffer strip design. Western Forester 27:12-14.

Oregon Forest Industries Council. 1999. FEMAT (forest ecosystem management assessment team) riparian process effectiveness curves: what is science-based and what is subjective judgement? Prepared by CH2MHill, Portland, Oregon, and Western Watershed Analysis, Lewiston, Idaho, for Oregon Forest Industries Council, Salem, Oregon.

Packer, P.E, 1967. Criteria for designing and locating logging roads to control sediment. Forest Science 13(1):2-18.

Robison, E.G. and R.L. Beschta. 1990. Identifying trees in riparian areas that can provide coarse woody debris to streams. Forest Sciences 36:790-801.

Steinblums, I.J., H.A. Froehlich, and J.K. Lyons. 1984. Designing stable buffer strips for stream protection. Journal of Forestry 82:49-52.

Sugden, B.D. and R.L. Steiner. 2003. Effects of current and historic forest practices on stream temperature. Pages 198-203 in Total Maximum Daily Load (TMDL) Environmental Regulations–II, Proceedings of the 8-12 November 2003 Conference, Albuquerque, New Mexico.

Sullivan, K., T.E. Lisle, C.A. Dolloff, G.E. Grant, and L.M. Reid. 1987. Stream channels: the link between forests and fishes. Pages 39-97. In: Salo, E.O. and T.W. Cundy (eds). Streamside management: forestry and fishery interactions. Contribution No.57. Institute of Forest Resources, University of Washington, Seattle, Washington.

Swift, L.W., Jr. 1986. Filter strip widths for forest roads in the southern Appalachians. Southern Journal of Applied Forestry 10(1):27-34.

USFS. 1995. Inland Native Fish Strategy, Environmental Assessment. USDA Forest Service, Intermountain, Northern, and Pacific Northwest Regions.